OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY **2805/02**

Applications of Genetics

Friday **23 JUNE 2006** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Read the questions carefully before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	15	
2	15	
3	15	
4	15	
5	15	
6	15	
TOTAL	90	

This question paper consists of 15 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 **(a)** A papaya plant, *Carica papaya*, may be male, female or hermaphrodite (both male and female).

The sex of the plants is determined by a single gene with three alleles:

- the dominant allele, **M**, results in a male plant
- a second dominant allele, $\mathbf{M^h}$, results in an hermaphrodite plant
- the recessive allele, **m**, when homozygous, results in a female plant.

All combinations of dominant alleles, **MM**, $\mathbf{MM^h}$ and $\mathbf{M^hM^h}$ are lethal, causing premature death of the plant embryos and resulting in non-viable seeds.

Use genetic diagrams to explain the following statements.

In each case, show the genotypes and phenotypes of the parent plants, the genotypes of the gametes and the genotypes and phenotypes of the offspring.

(i) Approximately half of the seeds produced by a plant developed into female plants.

parents

gametes

offspring

[3]

(ii) Approximately 25% of the seeds produced by a plant were not viable.

parents

gametes

offspring

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(iii) Approximately two-thirds of the seeds produced by a plant developed into hermaphrodite plants.

parents

gametes

offspring

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(b) Papaya fruit are an important commercial crop in many tropical countries. The wild relatives of *C. papaya* are found in tropical South America.

(i) Explain the **importance** of keeping seeds of the wild relatives of commercial crop plants, such as papaya, in a seed bank.

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(ii) Outline the main steps by which disease resistance could be selectively bred into commercially grown papaya.

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[Total: 15]

2 **(a)** Explain what is meant by *heritability*.

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(b) Rice plants may have, in addition to a main stem, a number of side shoots (tillers) growing from ground level. These tillers may also branch. The ability to grow tillers is controlled by a single gene with two alleles, **T/t**. Plants with the genotype **tt** have a single grain-bearing stem and no tillers.

Explain why the heritability of rice tiller growth is likely to be high.

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(c) Allele **T** codes for a protein which regulates transcription. Expression of allele **T** allows stimulation of mitosis in the buds which become tillers.

Allele **t** has a 'stop' triplet within its DNA sequence as well as at its end.

(i) State what is meant by a 'stop' triplet.

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(ii) Describe the effect of the 'stop' triplet **within** the DNA sequence of allele **t**.

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(iii) Suggest how the protein encoded by allele **T** may regulate transcription.

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(d) The number of tillers per plant and the number of times each tiller branched were recorded for wild type **TT** plants and for **tt** plants which had been given a copy of allele **T** by genetic engineering.

The results are shown in Fig. 2.1.

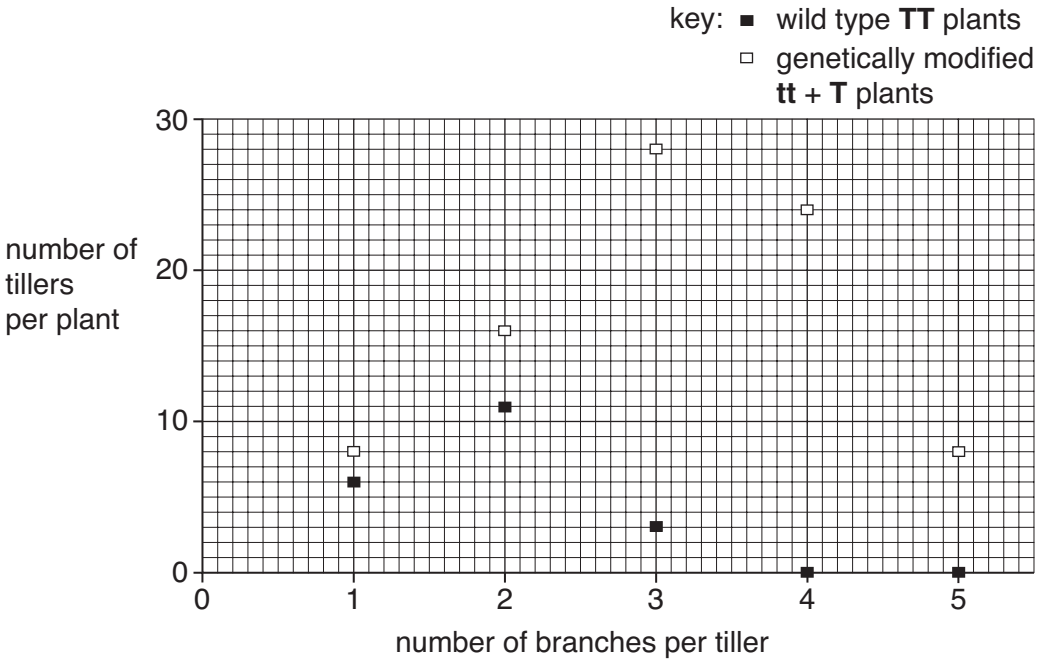

Fig. 2.1

(i) With reference to Fig. 2.1, compare the effect of the two rice genotypes on tiller growth.

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(ii) Suggest why the expression of allele **T** may be changed when it is transferred by genetic engineering into rice plants with the genotype **tt**.

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[Total: 15]

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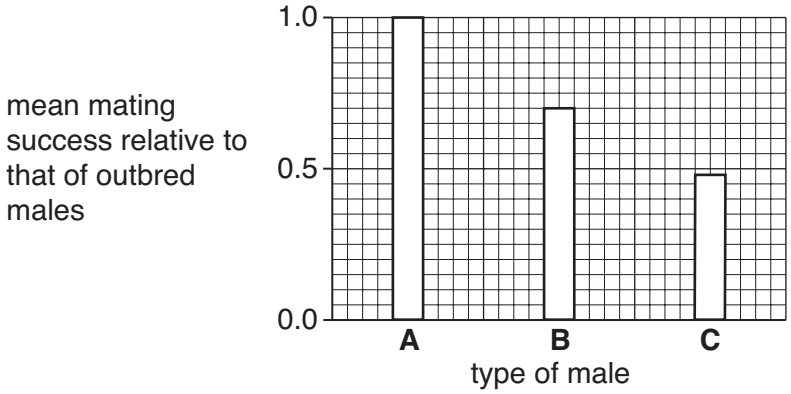
3 **(a)** An experiment was performed to compare the success in mating of outbred and inbred males of a small African butterfly, *Bicyclus anynana*.

Three types of male butterfly were used:
A - outbred
B - slightly inbred
C - highly inbred.

Equal numbers of the three types of male butterflies, **A**, **B** and **C**, were released into a large tropical greenhouse to compete for a small number of outbred females. Mating was observed and recorded and all the live males were recaptured after 48 hours.

The results are shown in Fig. 3.1.



	type of male		
	A	**B**	**C**
percentage recaptured	51	42	30

Fig. 3.1

(i) With reference to Fig. 3.1, describe the effect of inbreeding on the mating success of male butterflies.

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(ii) Explain the poor survival of inbred male butterflies in this experiment.

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(b) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Compare selective breeding with the evolutionary process.

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Quality of Written Communication [1]

[Total: 15]

4 **(a)** State what is meant by *in vitro* fertilisation (IVF).

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(b) In 2003, the Human Fertilisation and Embryology Authority (HFEA) in the UK restricted the number of embryos that may be transferred into a mother's uterus after IVF procedures to **two** for mothers under the age of 40 years.

Suggest why the HFEA restricted the number of embryos that may be transferred into a mother's uterus after IVF procedures.

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(c) In 2004, the outcomes of single and twin pregnancies following IVF were compared with those following natural conception in matched control groups of mothers. The review used data published between 1985 and 2002. Some of the results are shown in Table 4.1.

Table 4.1

	outcome per thousand pregnancies			
	single pregnancies		twin pregnancies	
	IVF	natural conception	IVF	natural conception
premature births	11.4	6.1	50.0	45.6
mortality of fetus or newborn baby	12.4	8.0	20.8	28.3

(i) With reference to Table 4.1, compare the outcomes of single and twin pregnancies after IVF and natural conception.

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twin pregnancies .....

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(ii) Explain whether or not the results shown in Table 4.1 suggest that the recommended number of embryos implanted after IVF should be further reduced to one.

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(d) The technique of artificial insemination (AI) is commonly used to overcome some of the problems of breeding livestock.

Discuss the advantages of using AI in breeding livestock.

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5 **(a)** Flowering plants have chemical communication systems.

(i) Outline the nature of chemical communication within flowering plants.

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(ii) Explain why plants need such a communication system.

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(b) Celery plants produce chemical signals when attacked by herbivorous insects. The signals switch on the plants' resistance genes that code for insecticides.

(i) Suggest why celery produces its insecticides only when attacked by insects.

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(ii) Outline the steps by which resistance to an insecticide may arise and spread in an insect population.

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(c) When eaten by insects such as the larvae known as earworms, celery plants produce the chemical signal jasmonate (**J**). This stimulates insecticide production. Insecticide begins to build up in the leaves after 24 hours and reaches maximum concentration after 4 to 5 days.

However, earworms become resistant to this insecticide by switching on a gene in the gut lining that codes for an enzyme (**E**) to break it down.

Newly hatched earworms were divided into four groups:

- **not** exposed to **J** but fed on celery leaves containing insecticide
- **not** exposed to **J** but fed on celery leaves with **no** insecticide

- exposed to **J** and fed on celery leaves containing insecticide
- exposed to **J** and fed on celery leaves with **no** insecticide.

The earworms continued to feed on these diets until they pupated.

The percentage mortality of the different groups of earworms and the relative expression of the gene coding for enzyme **E** are shown in Table 5.1. In the table, a tick (✓) indicates the presence of insecticide in the celery leaf diet and a cross (✗) indicates its absence.

Table 5.1

group of earworms	presence of insecticide in celery leaf diet	relative expression of gene coding for enzyme **E**	mortality/%
not exposed to **J**	✓	1.0	86.7
	✗	0.0	15.6
exposed to **J**	✓	6.5	48.3
	✗	5.5	6.7

Using the information given, explain the differences in percentage mortality of the different groups of earworms.

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[Total: 15]

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6 **(a)** Duchenne muscular dystrophy (DMD) is a genetic disease caused by the absence of the protein dystrophin in muscle fibres. In the absence of dystrophin, muscle fibres gradually die.

A potential gene therapy for DMD involves injecting muscles with a viral vector carrying recombinant DNA (rDNA) for part of the normal allele for dystrophin.

Outline the formation of recombinant DNA.

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(b) Mice with the symptoms of DMD were given this gene therapy shortly after birth. Each mouse was injected with the viral vector in a muscle of one hind limb. The corresponding muscle of the other hind limb was injected with a buffer solution to provide a control.

The nuclei of muscle fibres that do not produce dystrophin move from the edge of the fibre to the centre. The fibres eventually die.

The percentage of muscle fibres with centrally placed nuclei was measured in fibres from treated and control muscles at different times after injection. The results are shown in Fig. 6.1.

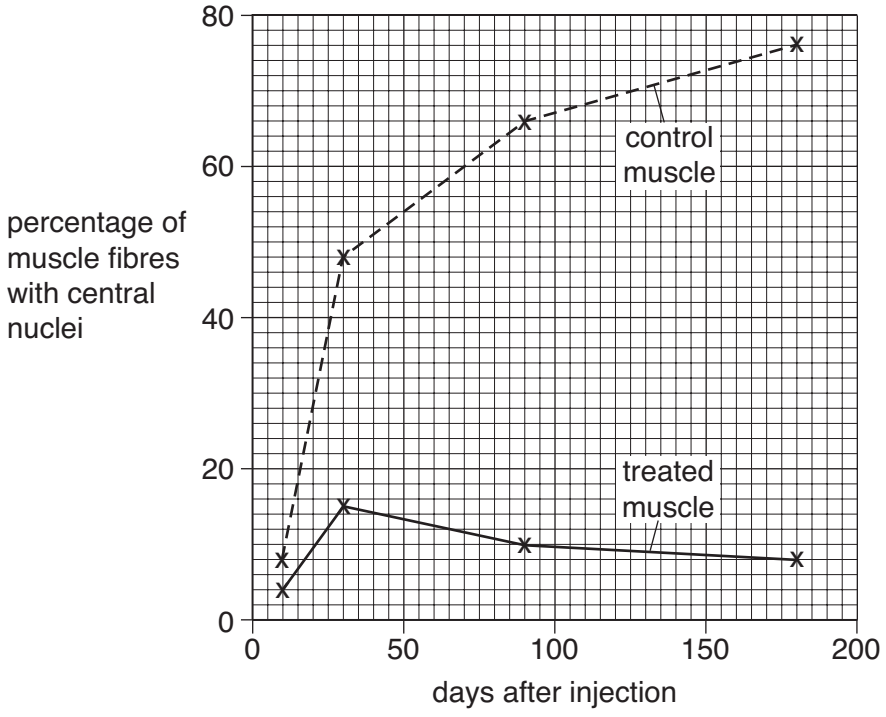

Fig. 6.1

Using the information in Fig. 6.1, describe the results of the experiment.

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(c) In this question, one mark is available for the quality of use and organisation of scientific terms.

Genetic screening is available for families with a history of DMD.

Discuss the advantages and disadvantages of genetic screening.

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For Examiner's Use

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Quality of Written Communication [1]

[Total: 15]

END OF QUESTION PAPER